

# The CERCular

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### Port St. Francis, South Africa: The First Completed CORE-LOC™ Prototype Structure

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#### Introduction

CORE-LOC™ was developed at the WES Coastal and Hydraulics Laboratory (CHL) in 1992 and patented in 1995 (Melby and Turk 1995, 1997). It is one of the most efficient concrete units for armoring breakwaters and jetties on the market today due to its efficient use of concrete, robust shape, reserve hydraulic stability, and single-layer application on the project. Since its inception, many breakwater armor layers have been designed using CORE-LOC™ and construction on several of those structures is beginning this year. The first CORE-LOC™-armored structures to be built are protecting Port St. Francis, in St. Francis Bay, South Africa. St. Francis Bay is located on the Indian Ocean side of the southern tip of the African continent.

Port St. Francis is a new privately developed small craft harbor, marina, and condominium resort. Figure 1 shows a recent aerial view of the site. The port site is just west of the famous surfing site featured in the cult-classic film *Endless*

*Summer*. In the film, the surfers stroll over the dunes to see the near-perfect, long-crested plunging waves. The dunes have been mostly vegetated since then, which has restricted the sand supply to the bay, resulting in erosion further into the bay and north up the coast.

The area where the port is being developed is a mostly rocky beach and shoreline. The port entrance and breakwaters were designed to have minimal impact on alongshore sediment transport.

The two protective structures at Port St. Francis include a breakwater and peninsula. The breakwater and peninsula CORE-LOC™ armor layers were designed to require 560 and 260 CORE-LOC™s, respectively. These two CORE-LOC™-armored structures have been subjected to four near-design level storms during construction. In addition, the construction process was fraught with problems as this was the first project of its kind for the contractor, who is also part owner of Port St. Francis. The structures



Figure 1. Aerial view of Port St. Francis, South Africa

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have fared well, in large part due to the capability of the CORE-LOC™ armor. This article summarizes the history of the design and construction process for the St. Francis project.

## Initial Design and Physical Model Study

The Port St. Francis breakwater armor layer was originally designed using 15-ton dolosse (plural, pronounced "dolosay"). The dolos (singular, pronounced "dolos") unit had been invented and widely used in South Africa, but recently the shape was modified according to research conducted in both the United States and South Africa. But the dolos unit is still weak in the central section and the dolos layer requires significantly more concrete than some of the more modern armor layers. The CORE-LOC™ unit solves the structural problems of the dolos and a CORE-LOC™ layer requires significantly less concrete. Additionally, CORE-LOC™ was designed to interlock with dolosse and, therefore, can be used as a repair unit for dolos armor layers (Turk and Melby 1995, 1997).

WES was contacted in mid-1995 by representatives of A.R. Wijnberg, Inc., about the possibility of substituting CORE-LOC™ for dolos for the St. Francis breakwater. A.R. Wijnberg, Inc., was the engineer of record for design and construction monitoring of the port project. Wijnberg engineers were anxious to recommend CORE-LOC™ as a cost-saving alternative for the project, having extensively tested dolosse and other similar armor units while working at the CSIR/EMATEK<sup>2</sup> laboratory in Stellenbosch, South Africa. Although Corps design guidance recommended a smaller CORE-LOC™ than the design dolos, an equivalent-sized CORE-LOC™ was conservatively recommended.

The physical modeling of CORE-LOC™ stability for this project

began in July of 1995, and a CHL engineer participated in the study. The experiment was conducted in the multidirectional wave basin at the CSIR/EMATEK laboratory in Stellenbosch. The Froude-scaled model was constructed using a physical length scale of 1-to-60 (model-to-prototype). The model CORE-LOC™s, weighing 67 gm, were constructed onsite specifically for this project. A stereo lithographic process was used to construct the CORE-LOC™ casting unit and molds were built using polyurethane rubber. Approximately 500 model units were molded using a mixture of barite powder and fiberglass resin.

The wave conditions tested included a prototype design condition of a long-crested swell from the west northwest with an offshore significant height of 7 m and a mean period of 16 sec. A depth-limited breaking wave was produced for these design conditions along the length of the structure where the toe depth ranged from 3 m to 7 m, prototype. The armor layer was stable for the design wave conditions. Prolonged duration tests were conducted to determine the reserve capacity with respect to stability of

the armor layer. The tests indicated that the transition area near the root of the breakwater could be susceptible to destabilization if not buttressed properly.

The peninsula was originally planned to be armored with a mobile stone berm, but the hardness of the quarry stone was not sufficient to resist degradation. As such, a CORE-LOC™ armor layer was designed. Tests were continued to determine optimal characteristics of both the breakwater and the peninsula.

## Construction of Prototype CORE-LOC™s

The CORE-LOC™ forms were designed by Form-Scaff, Inc., of South Africa. The form design featured a two-piece shell that separated down the middle, with the form halves sliding horizontally apart along the concrete base (Figure 2). Ten forms were constructed of 6-mm-thick steel with an internal volume of 6.25 cu m. Forms were set up on one of four concrete casting pads each day and all 10 forms were poured (Figure 3). The high-early-strength concrete allowed the

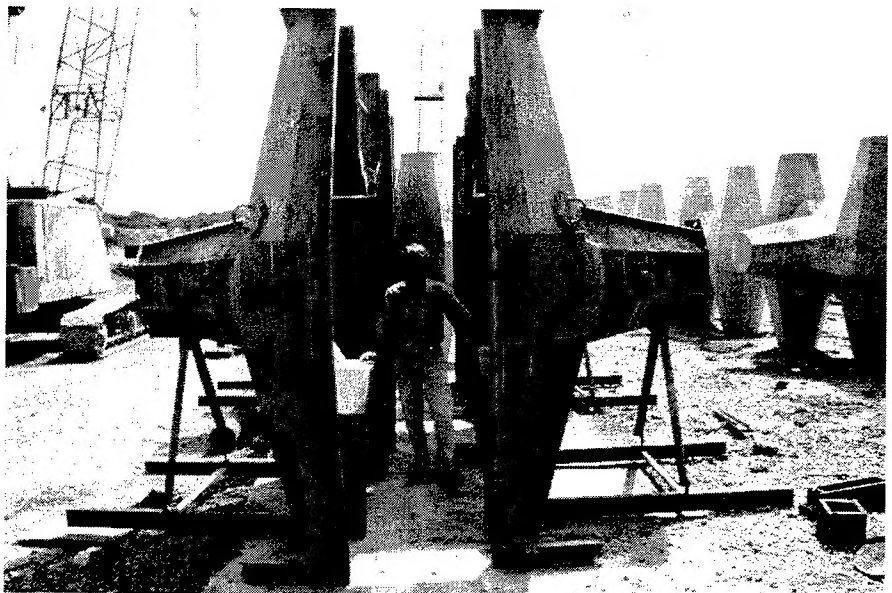


Figure 2. CORE-LOC™ forms in casting yard

<sup>2</sup> CSIR/EMATEK - Council for Science and Industrial Research/Earth, Marine, and Atmospheric Science and Technology Division, South African Government Research Organization.

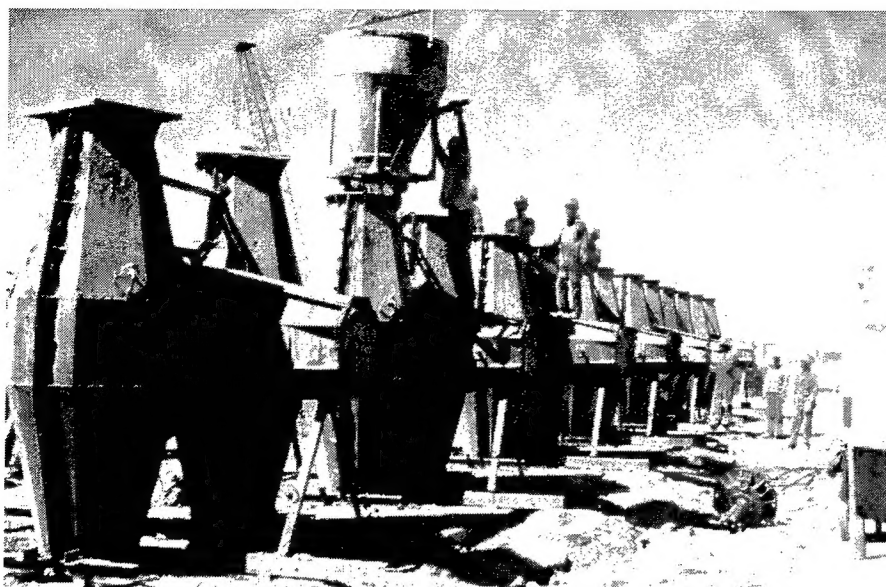


Figure 3. CORE-LOC™s being cast

forms to be stripped after curing 6 hr. The four pads assured that each run of 10 CORE-LOC™s could be left unmoved and cured for at least 48 hr before being moved to the storage yard where the CORE-LOC™s were set in long lines. Originally the form noses were left open on top, but plastic settlement cracks occurred in the chamfer region on nearly half of the first 100 CORE-LOC™s, indicating that the concrete was swelling out of the top of the noses during overnight curing. A CHL representative onsite recommended during the initial casting that the form noses be covered and those covers be secured. The contractor was not anxious to do this, so nearly 200 units were cast before all forms

were fully modified. The concrete specifications included a 28-day flexural tensile strength of 4 MPa (580 psi) and a 28-day compressive strength of 40 MPa (5,800 psi). Six successful design mix trials and six successful construction mix trials were performed before the concrete batch plant was deemed acceptable. Strength, slump, density, and air content were checked during these trials. During production, out of each 30 cu m of concrete batched (approximately five CORE-LOC™s), three cubes were cast for 28-day compressive strength tests, one cube for 7-day compressive strength test, and one beam for 28-day tensile strength test. Thus, test samples were cast approximately twice per day. In addition, every

fifth test included three additional cubes and three additional beams for 90-day compressive and tensile strength tests, respectively.

## Construction of Prototype Breakwater and Peninsula

A typical cross section for the breakwater is shown in Figure 4. This is the section at the deepest portion of the breakwater head. The underlayer was specified with a mass ranging from 0.5 ton to 2.5 tons, and a median mass of 1.5 tons. Construction of the breakwater began in April 1996, and started from the landward end working seaward. The core and underlayer material was dumped from a skip on a grid whose coordinates were monitored by the crane operator by reading crane boom horizontal angle and radius from digital readouts in the crane cab. These readings were acquired using potentiometers mounted on the crane. Initially, this monitoring system worked poorly. Additionally, the actual underlayer stone weights deviated considerably both on the low and high side from the specification. The combination of the underlayer stone weight being outside of the specification and the dumping process made for a highly irregular underlayer at the outset. The CORE-LOC™s were also placed on a grid using the same electronic monitoring system. The CORE-LOC™s were placed using both single- and

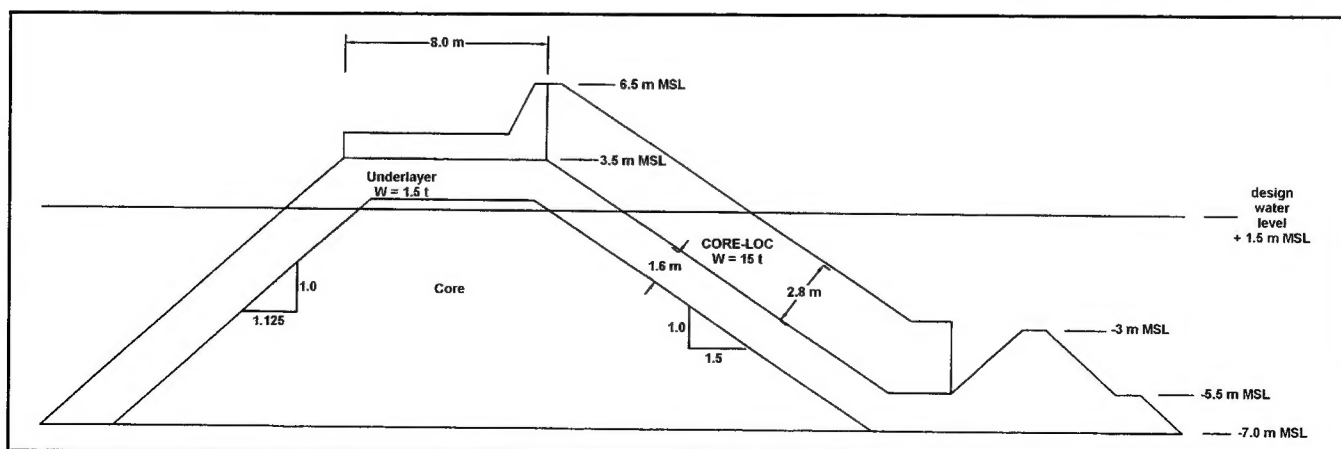


Figure 4. Typical cross section of Port St. Francis, South Africa, breakwater

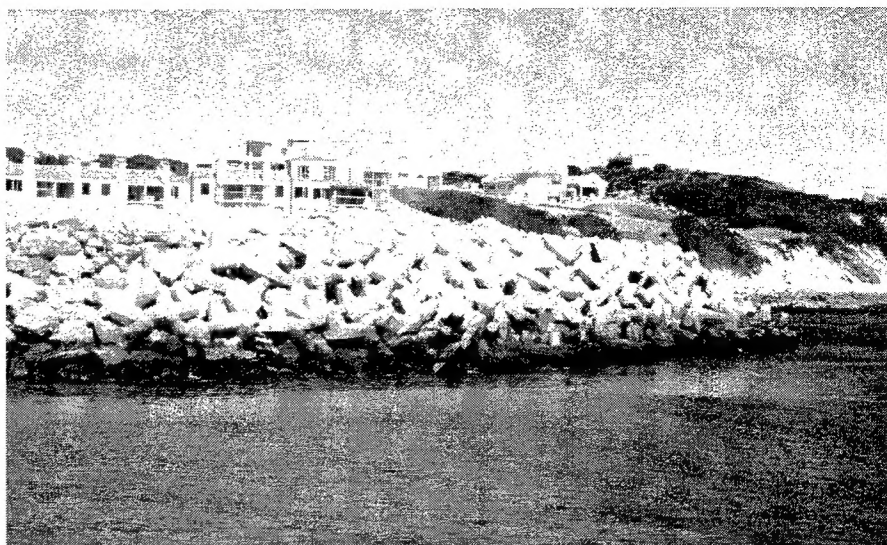
double-sling methods on a horizontal row grid spaced at 3.5 m, and an upslope grid spaced at 1.8 m. CORE-LOC™s were placed to an elevation of +3 m mean sea level. The last two rows of CORE-LOC™s were placed after completion of the cap and wave splash screen.

The CORE-LOC™ armor layer on the peninsula was completed during the latter part of 1996 (Figure 5). The peninsula armor layer quality was exceptional, as the contractor had become very proficient in his underlayer and armor layer construction methods.

During construction, the site saw four design-level events. The first design-level event occurred in June 1996, not long after CORE-LOC™ placement began. The CORE-LOC™s performed well with some minor displacements at the outer end of the construction. Waves pounded the trunk of the breakwater and emergency repairs were made to the core-stone crest. The second design-level event occurred in July 1996. During this storm significant settlement of the CORE-LOC™s occurred along the breakwater and five CORE-LOC™s were broken. Wijnberg engineers reported that one of these units failed in two sections of one third and two thirds the original mass. The remaining four units failed such that only a tip of a member broke off. These four units remained functional. The breakage was primarily due to settlement which was hypothesized to be the result of poor placement.

A careful inspection of the breakwater in January 1997 by CHL, CSIR/EMATEK, and Wijnberg engineers counted five additional broken units. All of the broken units were deemed functional and well interlocked and left in place. All engineers in attendance were impressed with the performance of the armor layer, considering the circumstances, and were in agreement that the broken units were still functional.

The third design-level event occurred in April 1997 and the fourth in June 1997. The June storm was so severe that the portion of the breakwater where the



**Figure 5. CORE-LOC™ armoring on Port St. Francis, South Africa, peninsula**

cap and wall had not yet been constructed was eroded (due to overtopping) from the inside shoulder of the breakwater seaward to the CORE-LOC™s. Many CORE-LOC™s were displaced back into the breach, and several broken units were observed. Otherwise, no significant settlement of the CORE-LOC™s occurred during this storm on the intake portion of the main breakwater or on the peninsula.

The CORE-LOC™ breakage on the breakwater was due to a combination of exposure of a partially complete section to design wave conditions and poor placement. The reconstruction of damaged sections went badly and the final as-built structure condition is only fair. An inspection of the breakwater in October 1997 by CHL, CSIR/EMATEK, and Wijnberg engineers counted 14 broken units, 10 of which were in the June breach section. It was clear that units that had tumbled into the breach section and broken had been placed back on the breakwater. The Contractor and Engineer have since reached a settlement which indicates the as-built breakwater will sustain at least one design event and 10 extra units and forms will remain available to allow for emergency repairs, should further damage occur.

## Future Plans

A monitoring program is being developed for the two structures at Port St. Francis. CSIR and CHL staff are coordinating a survey which will include monitoring for breakage, crane and ball survey, and overflight photography. Photogrammetric surveys may be done if funding permits.

Other CORE-LOC™ projects under consideration at present include the following:

- a. Fogo Island, Cape Verde, where 12-ton unreinforced CORE-LOC™s are being used to repair a breakwater that was previously armored with 6-ton tetrapods, but nearly destroyed.
- b. Manasquan, New Jersey jetties, where 18-ton, steel-rebar-reinforced CORE-LOC™s are being used to repair 14.4-ton dolosse.
- c. Khaboura, Oman, where 7-ton unreinforced CORE-LOC™s are being constructed for a horseshoe-shaped offshore breakwater.
- d. Dhalkut, Oman, where 15.8-ton unreinforced CORE-LOC™s for the trunk and 21.1-ton unreinforced CORE-LOC™s for the head have been proposed to armor a 1-km-long breakwater.
- e. Cleveland, Ohio, where a stone layer is being reinforced with options for stone or 3.6-ton unreinforced CORE-LOC™s.

f. Maalaea, Maui, Hawaii, where 14-ton unreinforced CORE-LOC™s have been proposed.

g. Kamalapau, Lanai, Hawaii, where 34.6-ton unreinforced CORE-LOC™s have been proposed and physically modeled for rehabilitation of a mostly stone breakwater.

h. Noyo, California, where 16.5-ton and 31.4-ton unreinforced CORE-LOC™s have been proposed and physically modeled to armor an offshore breakwater.

## Conclusion

The use of CORE-LOC™ at Port St. Francis, South Africa, has proven to be very successful

despite a number of difficulties in construction. The breakwater and peninsula armor layers have withstood four near-design storms during construction with little damage to either structure. Other CORE-LOC™ projects have been proposed in South Africa, and CSIR/EMATEK is currently performing research on the use of CORE-LOC™ as a repair unit for dolosse.

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## Coastal Engineering Education Program Graduates

The third class of the Coastal Engineering Education Program (CEEP) recently graduated. The 1-year course is conducted once every 3 years by the U.S. Army Engineer Waterways Experiment Station (WES) Coastal and Hydraulics Laboratory (CHL) and Texas A&M University (TAMU). Students

successfully completing the course also receive a Master of Engineering degree from TAMU. The graduating students in the front row of the photograph below are (left to right) Karl Brown, Galveston District; Bradd Schwichtenberg, Los Angeles District; Lori Hadley, WES; Wendell Mears, Mobile District; and

Luis Moreno, Spanish Ministry of Transport. CHL and TAMU faculty are shown in the background. The next CEEP class will begin in the fall of 1999. Information regarding registration requirements may be obtained from Dr. Jim Pennington, (601) 634-3549.



# DAN-NY and DMSMART, Open-Water Dredged Material Placement Site Management Software

by James Clausner<sup>1</sup>, Scott McDowell<sup>2</sup>, and Brian May<sup>3</sup>

## Introduction

Effective management of open-water dredged material placement sites has become exceedingly challenging; this is particularly true for multi-user sites. Increased scrutiny by regulators and environmental groups demands a much higher level of accountability regarding the material that has been placed in the designated site, and its potential to migrate out of the site. To more effectively manage these open-water sites, particularly those receiving a variety of material types and those dealing with contaminated sediment capping projects, integrated systems for site management named DAN-NY (Disposal Analysis Network for New York) and DMSMART (Dredged Material Spatial Management Analysis Resolution Tool) have been or are being developed.

New York Harbor generates large volumes of dredged material from a variety of projects, some of which is sufficiently contaminated to require capping for ocean disposal. To assist in site management, the U.S. Army Corps of Engineers (USACE) New York District is developing a first-generation user-specific comprehensive site management software package, DAN-NY. DAN-NY consists of a commercially available, user-friendly GIS package, commercial database, standard and customized applications and output, and a previously developed Corps Dredging Research Program (DRP) model, MDFATE (Multiple Dump FATE) for predicting disposal mound geometries.

The Corps' Dredging Operations and Environmental Research (DOER) Program is presently developing an enhanced system similar to DAN-NY, but with expanded capabilities targeted for Corps-wide application. The Corps-wide system is DMSMART. The major difference between DMSMART and DAN-NY is the addition of information on the dredging site and access to all the PC-based fate models developed by the DRP (STFATE (Short-Term FATE), MDFATE, and LTFATE (Long-Term FATE)) and all the DRP databases.

## New York District Site Management

Open-water sites for placement of dredged sediments are selected and managed to facilitate necessary dredging and the subsequent placement of the dredged sediments, while minimizing potential adverse impact to the aquatic environment. For many navigation projects that are vital to the nation's economic health, placing dredged material in open-water sites is often the least costly alternative. However, as public awareness and concern regarding the aquatic environment have increased (particularly when the sediments possess some degree of contamination), open-water placement of dredged sediments has become the subject of increased environmental concern. Continued use of aquatic sites for placement of dredged sediments may depend on the Corps' ability to effectively manage dredged sediment placement sites, and on the perception of how well the Corps' management

policies and practices protect the aquatic environment and, ultimately, human health.

Historically, the New York District has been a very difficult open-water site to manage. The Mud Dump site is a 1- x 2-n.m. rectangle located 6 n.m. east of Sandy Hook, NJ, and its use as a disposal site predates its interim designation in 1973. The site was finally designated in 1984 and assigned a capacity of 100 million cu yd. The site's proximity to commercial and recreational fishing areas, historic disposal sites, and heavy shipping through the approaches to New York Harbor create a unique set of circumstances from a site management perspective. For most of the time since site designation, the site has received an average of 5.8 million cu yd per year of mostly fine-grained maintenance material (Massa et al. 1996), from at least 20 federal and private projects. Material is typically mechanically dredged, placed in bottom dump barges, and transported to the Mud Dump site for placement. Placement locations within the site are marked with taut-moored buoys. Based on surveys and barge log volumes, the buoys are periodically moved to prevent excessive mounding above a preset minimum for safe navigation.

The first major need related to site management pertained to the necessity to maximize site capacity while containing the sediments inside the site and maintaining safe navigation depth. This was the major driving factor for developing a computerized GIS system to provide a much more sophisticated level of site management. By the

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end of 1995, approximately 68 million cu yd of material had been placed in the Mud Dump site, resulting in considerable mounding in the northern half of the site (over 30 ft in some places) with several areas approaching the minimum navigable depth of 45 ft. As part of their effort to increase site capacity, New York District and the U.S. Environmental Protection Agency (EPA) investigated a number of options to expand site capacity.

The second major need at the Mud Dump site concerned contaminated dredged materials. Prior to 1989, chemical and biological testing protocols resulted in the vast majority (90 to 95 percent) of the sediment dredged from New York Harbor being classified as suitable for unrestricted ocean disposal. Implementation of the revised ocean dumping regulations in 1991 (USACE and EPA 1991) required more sensitive chemical and biological testing of the sediments, and significantly increased the volume of New York Harbor sediments classified as sufficiently contaminated that they could no longer have unrestricted open-water placement. These Category II dredged materials were allowed to be placed in the ocean through September 1997, the closure date for the site, only if capped with clean material.

The third major need for an integrated system of site management resulted from the variety of different locations and media on which the District stored information relevant to site management. Bathymetric surveys are available as hard copies in the District office in New York City, and resided in electronic format at the District survey branch in the Caven Point, NJ, field office. Barge logs are received as hard copies, from which limited data are converted to spreadsheets. Other pertinent information resides in reports, files, etc. Managing all of these data sources so that useful information can be produced is extremely difficult.

## DAN-NY

WES and Science Applications International Corporation (SAIC) have supported the New York District in site management activities for many years. SAIC has been responsible for collecting a highly significant amount of monitoring data at the Mud Dump site and operational planning for capping operations, while WES has assisted in capping project design (Randall, Clausner, and Johnson 1994) and computations of site capacity (Clausner and Greges 1995). In 1994, SAIC proposed joint development of a GIS-based system for assisting the District with open-water site management (DAN-NY). In the joint effort, SAIC expertise in monitoring and data collection were combined with Applied Science Associates (ASA), a firm specializing in hydrodynamic numerical modeling using geographic information systems (GIS), and WES' capping, fate modeling, and site capacity determination capabilities.

DAN-NY was developed in four phases. Phase I (completed in May 1996 (SAIC 1996)) was a system design study which defines data types, hardware, software, costs, and schedules for implementing subsequent phases. Phase II consisted of system design and implementation, including development of documenting data management systems and training of District and WES staff. Phase III was performed concurrently with Phase II, and selected the required data and populated the databases. Phases II and III were completed in June 1997. Phase IV will maintain the system, add enhanced software and analysis, continue populating the database with additional data sets, and add a capability to access data collected with the New York Disposal Surveillance System (NYDISS), a barge-mounted silent inspector system for determining barge location during disposal.

DAN-NY has both (a) quick access to maps and summary information that can be used by upper level management, and (b) extended capabilities for the technical user (i.e., the District site manager or

WES technical expert). Quick access features allow the user to view the most recent bathymetric surveys in the database. The user can then print a high-quality map in black and white or color. The user will be able to select from a series of bathymetric surveys and compute, display, and print the depth difference map between the two surveys. This will show what material has accumulated or eroded between the two surveys. A subset of the disposal logs can be selected with the positions displayed on the current site bathymetric map. In the extended capabilities mode, the site manager or WES technical expert will have access to an array of tools that will apply to many day-to-day activities as well as longer-term planning and design-related studies. Figure 1 shows the range of tasks that can be done by DAN-NY. In addition to the more obvious abilities to display bathymetric survey data in a wide range of options, DAN-NY can compute site capacity, predict mound geometry using the DRP- developed MDFATE model (Moritz and Randall 1995), display the mound created and compute volumes associated with buoy locations, review barge disposal logs, view sediment profile images, and perform other site-specific tasks.

DAN-NY is based on commercially available software plus specialized applications developed by SAIC and ASA. The software (all 32-bit) includes a Windows 4.0 NT Operating System, ArcView 3.0 GIS, Microsoft Access Database, and Microsoft Visual Basic Applications. The hardware includes a 166-MHz Pentium CPU, 32-mb RAM, 2-gb hard drive, two 6x CD-ROM drives, a 21-in. SVGA monitor, and an HP Deskjet 870C color printer.

The beta version of DAN-NY, delivered in June 1997, was used to assist in the design of the capped Category II mound project placed in the Mud Dump site during the summer of 1997. This early version of DAN-NY proved to be extremely valuable in determining the operational plan for placing an estimated 240 barge loads containing nearly 1 million cu yd of Category II material, which will be

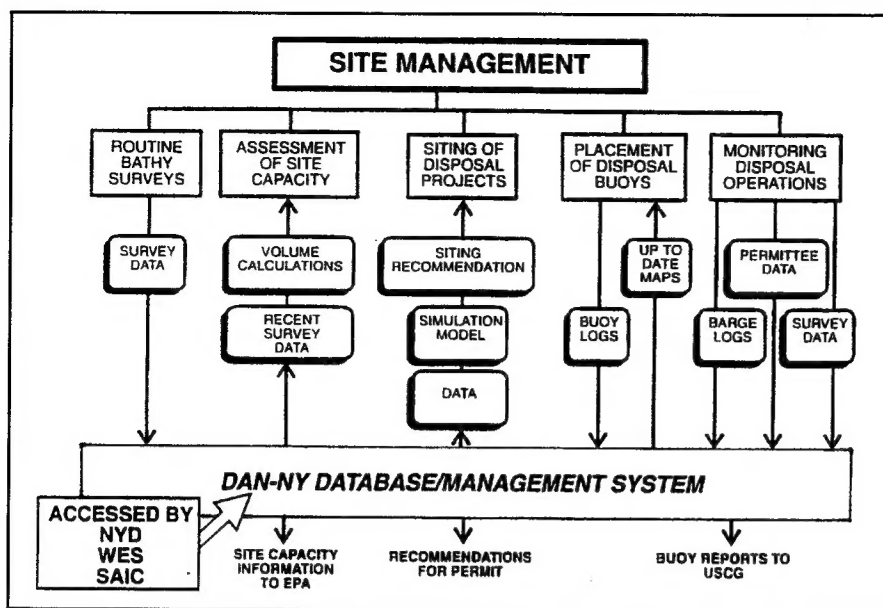


Figure 1. Site management activities supported by DAN-NY

capped by approximately 2 million cu yd of sand.

## DMSMART

As part of the DOER Program, WES is developing a Corps-wide integrated site management system, DMSMART. DMSMART will build on the experience gained from DAN-NY. Because of the complexity of the New York District site management problems, DAN-NY already has many features helpful to other Corps Districts that will be incorporated into DMSMART.

DMSMART will expand upon DAN-NY in several areas, including dredging project location, channel dimensions, volumes, and historical dredging data (e.g., grain size distributions, past volumes, contractors and equipment used, production rates, etc.). Chemical and biological testing data also will be available.

DMSMART will include access to all the dredged material fate models needed for open-water site management, seamlessly exporting data from one model to another. Existing models to be included are STFATE, MDFATE, and LTFATE. STFATE (Johnson and Fong 1995) predicts the fate of dredged material (bottom footprint and thickness, and water column concentrations of chemicals) from a single disposal of a

barge or hopper dredge. STFATE is now available in the Automated Dredging and Disposal System (ADDAMS) (Schroeder and Palermo 1990). Other ADDAMS programs can be incorporated later as necessary. MDFATE predicts the bottom mound resulting from repetitive dumping. MDFATE includes versions of both STFATE and LTFATE (Scheffner et al. 1994). LTFATE predicts behavior of a dredged material mound for up to 1 year. The full version of LTFATE will be included in DMSMART, which can then model dredged material mounds for decades. LTFATE algorithms will be significantly enhanced under the DOER program, to include consideration of fine-grained sediments and a mix of fine-grained sediments and sand.

ADCIRC (ADVanced CIRCulation) (Westerink et al. 1994) predicts tidal and storm-induced currents over large areas, and also predicts tide and storm surge elevations. ADCIRC has been previously used to generate databases of tidal constituents and tropical and extratropical storm surges (Scheffner et al. 1994; Westerink, Luettich, and Scheffner 1993). An effort will be made to make these databases accessible by DMSMART to drive the dredged material fate models. The WES Wave Information Study database has archived wave data

from sites around the U.S. coastline, and will be available to DMSMART.

DMSMART is being developed in two phases. During Phase I, MDFATE, LTFATE, and STFATE will be incorporated, along with the ADCIRC and WIS databases and limited information from the dredging site. Beta versions of DMSMART 1.0 and the user's manual will be distributed to Corps Districts for testing and response. After beta evaluation, a decision will be made whether to proceed with full development.

If a decision is reached to proceed with Phase II, then DMSMART will be more fully developed for Corps-wide application. Additional dredged material and operational models developed under DOER will be incorporated, and DMSMART will be interfaced with Silent Inspector technology. This will allow the site manager to access archived data on the performance of the dredge (hopper, cutter head, mechanical) including location, status, etc. With the Silent Inspector link, the site manager can verify that the dredge removed and placed material in the proper locations. Thus, it will be much easier to monitor contractual requirements and compliance with EPA regulations.

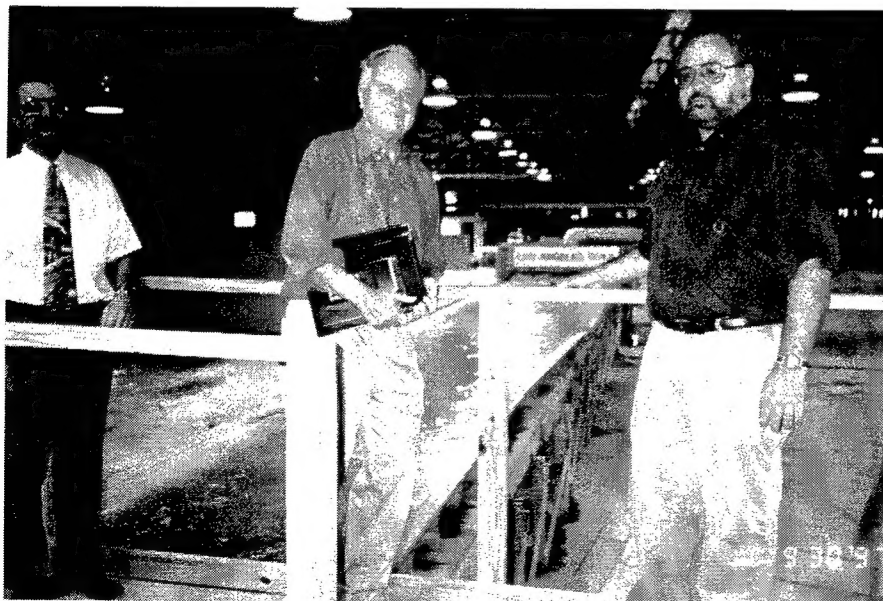
## Summary

Management of open-water dredged material placement sites is exceedingly complex. Recent advances in computer hardware and software have made possible GIS-based software to assist in managing open-water disposal sites. Site management problems led the New York District to fund development of a District-specific site management software system, DAN-NY. Under the ongoing DOER research program, WES is developing a Corps-wide open-water site management software (DMSMART). Based on experience gained from DAN-NY, DMSMART will include the latest versions of all pertinent dredged material fate models and

all databases regarding the dredging sites.

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**Los Angeles Mayor Richard Riordan (center) visits the Los Angeles County Drainage Area physical model with Charles Tate, WES Coastal and Hydraulics Laboratory (CHL) project manager (right), and Dr. James R. Houston, CHL Director (left). Mayor Riordan also visited the Los Angeles/Long Beach Harbor physical model.**

# The Coastal Engineering Manual: A Replacement for the Shore Protection Manual

by Joan Pope<sup>1</sup>

## Introduction

During the past two decades coastal engineering practices in the U.S. Army Corps of Engineers (USACE) and standard engineering for most coastal projects throughout the world have been based on the *Shore Protection Manual* (SPM). Since the SPM was first published in 1973 (most recent update in 1984), the field of coastal engineering has witnessed many technical advances and an increased emphasis on environmental and project maintenance-oriented coastal engineering applications.

In order to develop a "modern" technical document which incorporates all the tools and procedures used to plan, design, construct, and maintain coastal projects, the U.S. Army Engineer Waterways Experiment Station (WES), Coastal and Hydraulics Laboratory (CHL) is undertaking a multi-year program to produce the *Coastal Engineering Manual* (CEM), to replace the SPM. The CEM will include the basic principles of coastal processes, methods for computing coastal engineering planning and design parameters, and guidance on how to develop and conduct studies in support of coastal storm damage reduction, shore protection, and navigation projects. The CEM is intended to provide broader coverage of all aspects of coastal engineering than that currently found in the SPM.

## The Shore Protection Manual (SPM)

In the United States, USACE traditionally has been responsible for

constructing and maintaining Federally authorized coastal civil works projects including harbor entrance channels, navigation channels, and coastal storm damage reduction and shore protection projects. USACE therefore has been responsible for developing the principles of coastal engineering as they are practiced in the United States. In 1929, USACE created the Board on Sand Movement and Beach Erosion to study the problems of coastal erosion. This led to legislation founding the Beach Erosion Board (BEB) in 1930. In 1963, Congress replaced the BEB by establishing the Coastal Engineering Research Center (CERC) (Moore and Moore 1991). In 1996, CERC was combined with the USACE Hydraulics Laboratory to form CHL. It has been the responsibility of these organizations to develop basic principles and engineering guidance for coastal engineering in the United States.

The first consolidated guidance on coastal structure design was the BEB "Shore Protection Planning and Design" (U.S. Army Corps of Engineers 1954). This was the forerunner of the SPM (1973) which was revised in 1975, 1977 and 1984. The first edition of the SPM, at 1,160 pages in length, was almost three times as long as the 20-year-old TR-4 (Camfield 1988). Although USACE, CERC, and CHL have continued to produce coastal engineering guidance and technical documents, these are specific to a particular subject matter and are usually used as a supplementary reference to the SPM.

Over the last two decades, the SPM has become the standard reference and resource for coastal

engineering in the United States and has also fulfilled a number of roles beyond its original intent. It provides the accomplished engineer with guidance on how to proceed with the planning and design of various coastal projects. It also is a convenient reference for the use of empirical procedures to compute a particular design parameter. The SPM is commonly used as a university textbook and as a training aid for apprentice engineers. Approximately 30,000 copies have been sold through the U.S. Government Printing Office. The number of translations into other languages, including Chinese and even Catalanian (Spanish), further attests to the SPM's role as an international standard guidance for professional coastal engineers.

The SPM has amassed an army of users and a long history of projects built according to its content. However, it was written before many of the recent advances in irregular wave theory, personal and high-performance computers, sediment transport concepts, numerical simulation techniques, reliable oceanographic measurement systems, and environmental awareness. Although the SPM is a general coastal engineering reference, its primary focus is shore protection. Thus, some aspects of navigation and harbor design were not included. Significant research and development advances and the range of project challenges which modern coastal engineers address has expanded since the last update of the SPM. Consequently, in 1992 USACE started development of a replacement for the SPM, the Coastal Engineering Manual (CEM).

<sup>1</sup> Chief, Coastal Evaluation and Design Branch, Coastal and Hydraulics Laboratory, WES.

## The Coastal Engineering Manual (CEM)

The CEM will be a comprehensive, state-of-the-art technical document which incorporates the tools and procedures used to plan, design, construct, and maintain coastal projects. This engineering manual will include the basic principles of coastal processes, methods for computing coastal engineering planning and design parameters, and guidance on how to formulate and conduct studies in support of coastal storm damage reduction, shore protection, and navigation projects. The CEM will provide broader coverage of all aspects of coastal engineering than the SPM. New sections are being added on navigation and harbor design, dredging and dredged material placement, structure repair and rehabilitation, wetland and low energy shore protection, cohesive shores, risk analysis, field instrumentation, numerical simulation, the engineering process, and other topics.

In order to be successful, the CEM must retain the diversity of users and multiple-use character of the SPM. Therefore, the CEM is being written at a level suitable for the baccalaureate civil/hydraulic engineer who has had no advanced academic training in coastal engineering or its related subjects. Although the target user group is USACE personnel involved in coastal project development and design, it is expected that this manual, like its predecessor, will be of value to coastal engineers and other specialists in academia and industry throughout the world. The philosophy behind preparation of the CEM is embodied in the CEM logo (Figure 1). The CEM will incorporate international technical advances and is being written, as much as possible, to be non-regional and non-United States specific in its presentation of basic coastal engineering issues and practices.

A particular challenge of the CEM will be to integrate the expand-

ing array of computer-based tools into the fundamentals of good coastal engineering practice. Although a number of software products may be referenced, only well-documented, publically available, and supported models will be presented in any detail. The discussion will tend to be generic to a particular category of models, with the main emphasis oriented toward software that is readily available to USACE engineers. Discussion in the CEM will include basic theoretical assumptions, input data requirements, output, limitations, references, and an example application. The CEM will not attempt to replace model user documents.

A revision and update process is being programmed into the CEM development rationale. The published, public-release form of the CEM has not been finalized. One possibility is to issue it in a loose-leaf form which would allow ready updates as modular sections are updated and replaced. Procedures to develop and release an electronic form are also being pursued. An electronic version could allow interactive use, easy linkage with analytical software, and ease of updates.

### Structure of the CEM

The CEM contains two major subdivisions: science-based parts and engineering-based parts. The science-based parts include "Part 2 - Coastal Hydrodynamics," "Part 3 -

Coastal Sediment Processes," and "Part 4 - Coastal Geology." These parts of the document provide the scientific foundation which the engineering-based parts will reference, and were prepared first. "Coastal Hydrodynamics" is organized to lead the reader from the fundamental principles of wave theory and ocean wave generation through the process of transformation as the wave approaches and reacts with the coastline. Water level variations and currents are included in this part of the document. "Coastal Sediment Processes" includes major chapters on longshore and cross-shore transport, as well as chapters on shelf, cohesive, and wind transport processes. "Coastal Geology" includes chapters on geomorphology and analytical field techniques.

The two engineering-based parts of the CEM ("Part 5 - Coastal Project Planning and Design" and "Part 6 - Coastal Structure Design") are oriented toward a project-type approach, rather than the individual structure design approach which characterized the SPM. The proposed architecture and substance of the engineering-based parts is the result of an internationally attended workshop held in February 1994. Approximately 20 coastal engineers from academia, government, and consulting firms participated. As a result of this workshop, a logical system-based approach was designed for the engineering structure of the CEM. This approach will mirror the engineering process with guidance in selecting and utilizing various planning and design tools as appropriate for the project at hand. These engineering tools will be presented in modular grouping to allow for future updates as the technology continues to advance.

Technical area work teams scope and prepare each part of the CEM. The writing of each chapter is conducted or carefully monitored by CHL. Consultants and recognized experts in particular subject areas prepare or review each chapter. Peer reviews by research specialists, practicing coastal engineers, and USACE users are conducted throughout development of the



Figure 1. Coastal Engineering Manual logo

CEM. As each major part is completed, it is released as an interim document for use by USACE offices. These interim releases are used to gather comments on suitability and effectiveness. Each part will then be revised, updated, and consolidated into the overall document. The integration of the CEM is scheduled to occur in 1999, with final publication expected in 2000.

## Current Status

All science-based parts of the CEM ("Coastal Hydrodynamics," "Coastal Sediments," and "Coastal Geology") will be released by the end of 1997. "Coastal Geology" was

released in 1995 as a USACE Engineer Manual and "Coastal Hydrodynamics" was released in 1996. Most of the work in writing the engineering-based parts (5 and 6) will occur in 1997 and 1998. Current and additional information on the CEM, including a detailed outline of the report structure, is available via the Internet at <http://bigfoot.cerc.wes.army.mil/cem001.html>.

## References

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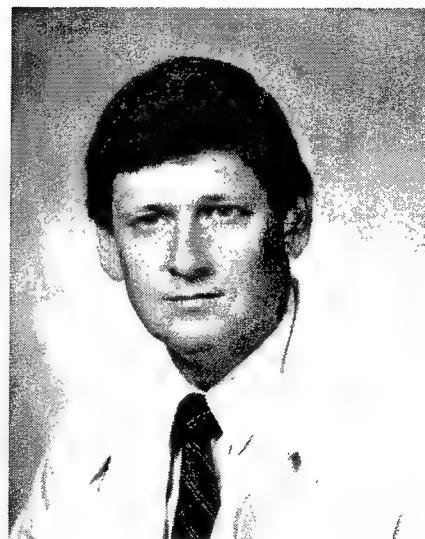
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## Stephen T. Maynard Receives ASCE Hydraulic Structures Medal

Dr. Stephen T. Maynard of the U.S. Army Engineer Waterways Experiment Station (WES) Coastal and Hydraulics Laboratory (CHL) received the 1997 American Society of Civil Engineers (ASCE) Hydraulic Structures Medal at the joint ASCE Water Conference/27th International Association for Hydraulic Research Congress in San Francisco in August. This national award is presented annually to a hydraulic

researcher who has made highly significant contributions to the advancement of the art and science of hydraulic engineering as applied to hydraulic structures. Dr. Maynard has been employed by the Corps of Engineers for 25 years, with the last 22 years being at WES where he has performed and directed major applied research in the area of hydraulic structure functionality and performance.

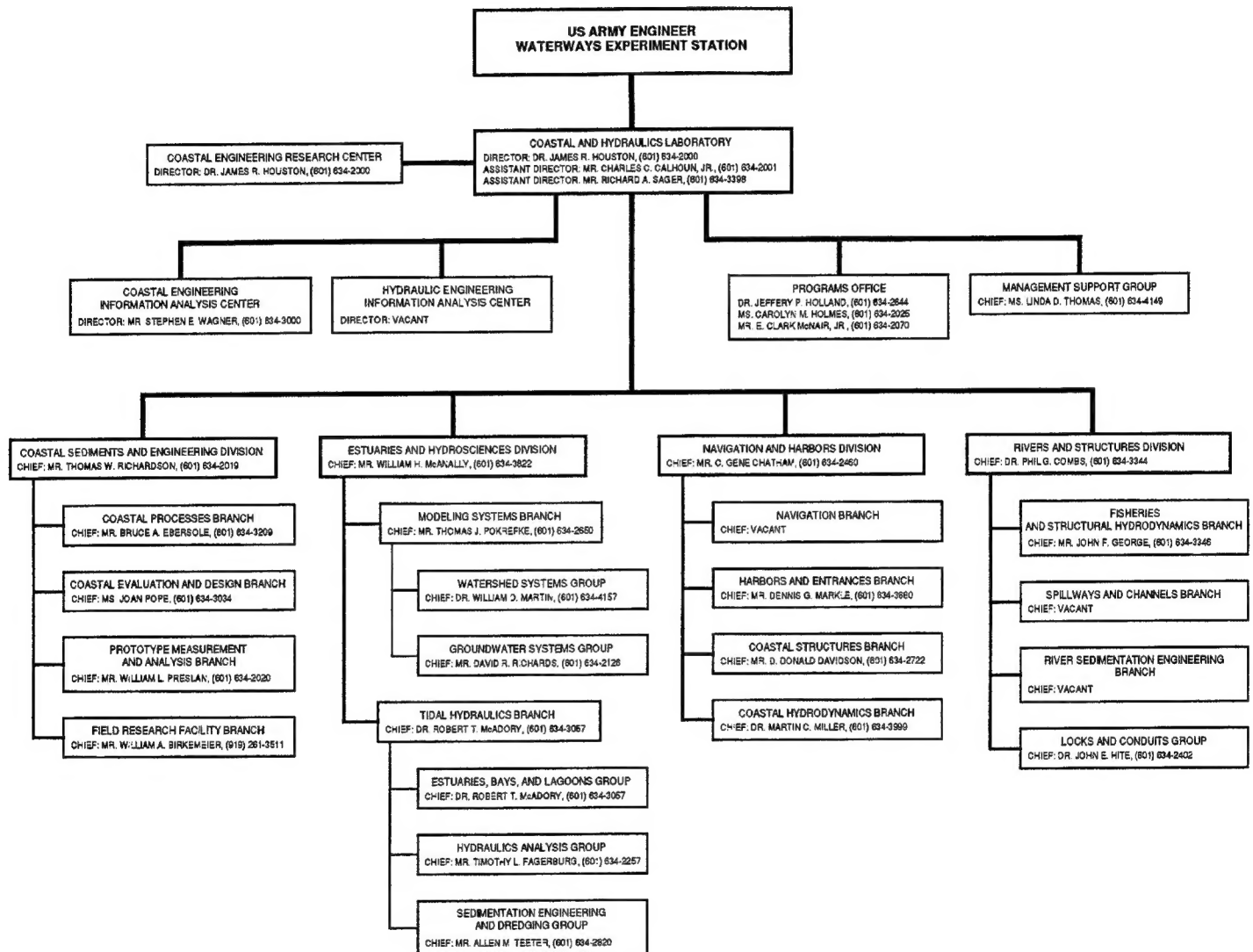


# Coastal and Hydraulics Laboratory Reorganization

In an earlier edition, the merger of the Coastal Engineering Research Center and the Hydraulics Laboratory into the Coastal and

Hydraulics Laboratory (CHL) was announced. That merger resulted in a laboratory composed of seven divisions. CHL was recently reorgan-

ized into four divisions, as reflected by the organizational chart that follows.



# 66th Meeting of the Coastal Engineering Research Board, 16-17 October 1997, New York, New York

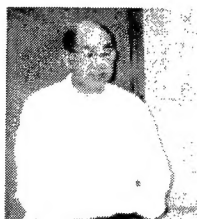
The 66th meeting of the Coastal Engineering Research Board (CERB) was held on 16-17 October 1997 in New York City. On the first day, the full Board viewed various coastal sites by air as well as on the ground. On the second day, the civilian members met with New York District engineers and scientists to discuss numerous projects.

The Board, Congressionally mandated to advise the Chief of Engineers on matters related to coastal engineering, is comprised of seven members. The President of the Board is MG Russell L. Fuhrman,

Director of Civil works. The other three military members are BG Henry S. Miller, Jr., Commander, Southwestern Division; BG J. Richard Capka, Commander, South Pacific Division; and BG Robert L. VanAntwerp, Commander, South Atlantic Division. The three civilian members are Dr. Robert G. Dean, University of Florida; Dr. Edward K. Noda, Edward K. Noda and Associates, Inc., Honolulu, HI; and Dr. Richard W. Sternberg, University of Washington. The Commander of the U.S. Army Engineer Waterways Experiment Sta-

tion, COL Robin R. Cababa, serves as the Executive Secretary of CERB.

A report of the meeting will be included in the Proceedings of the 67th meeting to be held in Florida the week of 11 May 1998. Since the proceedings will be on the Internet, hard copies will no longer be routinely sent to Corps offices or attendees. Hard copies may be obtained from Ms. Sharon L. Hanks, U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory, (601) 634-2004.



*Dr. Noda*



*COL Robin Cababa, Executive Secretary; Board Members: BG Richard Capka, Dr. Edward Noda, MG Russell Fuhrman, Dr. Robert Dean, Dr. Richard Sternberg, and BG Robert VanAntwerp*



*Dr. Dean*



*Diane Rahoy*



*Chris Rasmussen*



*Dr. Noda and MG Fuhrman*



*Arthur Connolly*



*Lynn Bocamazo*



*MG Fuhrman and Dr. Dean*



*Foreground: Dr. Sternberg and Dr. Noda*



*Charles Calhoun and Dr. James Houston*



*Ray Schembri*



*Cliff Jones*



*Dave Rackmales*



*Steve Couch*



*Bill Daley*



*Bernie Moore and Charley Chesnutt*

# Calendar of Coastal Events

- Dec 8 - 12, 1997 **American Geophysical Union, Fall Meeting**, San Francisco, CA, USA.
- Jan 5 - 9, 1998 **27th Annual Dredging Engineering Short Course**, College Station, TX, USA, POC: Robert E. Randall, Center for Dredging Studies, Texas A&M University, College Station, TX 77843-3136, phone (409) 845-4515, fax (409) 862-1542.
- Jan 27 - 30, 1998 **5th International Workshop on Wave Hindcasting and Forecasting**, Melbourne, FL, USA, POCs: Don Resio, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180, phone (601) 634-2018, fax (601) 634-4253, e-mail d.resio@cerc.wes.army.mil; Paul Wittman, Fleet Numerical Meteorology and Oceanography Center, Code 42, 7 Grace Hopper Avenue, Monterey, CA 93943-5005, phone (408) 656-4526, fax (408) 656-4489, e-mail wittmann@fnoc.navy.mil
- Feb 4 - 6, 1998 **National Conference on Beach Preservation Technology: 11th Annual Conference**, St. Petersburg, FL, USA, POC: Teri Besse, Beach Technology '98, 2952 Wellington Circle, Tallahassee, FL 32308, phone (904) 906-9227, fax (904) 906-9228.
- Feb 9 - 13, 1998 **1988 Ocean Sciences Meeting**, San Diego, CA, USA, POC: American Geophysical Union, Meetings Department, 2000 Florida Avenue NW, Washington, DC 20009, phone 1 800 966 2481 or +1 202 462 6910 ext. 215, fax +1 202 328 0566, e-mail meeting-info@kosmos.agu.org
- Mar 8 - 11, 1998 **PORTS '98: Transportation Link to Global Trade**, Long Beach, CA, USA, POC: Michael Kraman, MOFFATT & NICHOL ENGINEERS, 250 W. Wardlow Road, P.O. Box 7707, Long Beach, CA 90807, phone (310) 426-9551, fax (310) 424-7489, e-mail mkraman@moffattnichol.com
- Mar 15 - 21, 1998 **4th Marine/Estuarine Shallow Water Conference**, Atlantic City, NJ, USA, POC: email spagnolo.ralph@epamail.epa.gov
- Mar 19 - 20, 1998 **Coastlines, Structures, and Breakwaters**, London, England, POC: Sue Frye, Institution of Civil Engineers, One Great George Street, London, SW1P 3AA, UK, phone +44 (0)171 665 2315, fax +44 (0)171 233 1743, email ttconf@ice.org.uk
- Mar 20 - 29, 1998 **Wetlands Engineering & River Restoration Conference 1998**, Denver, Co, USA, POC: J. Craig Fischenich, USAE Waterways Experiment Station, ATTN: CEWES-EE-A, 3909 Halls Ferry Road, Vicksburg, MS 39180, phone 601-634-3449, e-mail fischec@ex1.wes.army.mil
- Apr 6 - 10, 1998 **National Hurricane Conference: 20th Annual Meeting**, Norfolk, VA, USA, POC: National Hurricane Conference, 2952 Wellington Circle, Tallahassee, FL 32308, phone (850)906-9224, fax (850)906-9228.
- Apr 13 - 17, 1998 **Fifteenth International Sedimentological Congress**, Alicante, Spain, POC: Departamento de Ciencias de la Tierra y Medio Ambiente, Facultad de Ciencias, Campus de San Vicente de Raspeig, Universidad de Alicante, Apartado 99.03080 Alicante, Spain
- Apr 30 - May 1, 1998 **1998 International Symposium on Ocean Wave Kinematics: Dynamics and Loads on Structures**, Houston, TX, USA, POC: Dr. Zeki Demirebilek, phone (601) 634-2834, email z.demirebilek@cerc.wes.army.mil; Dr. Robert E. Randall, email r-randall@tamu.edu
- May 25 - 29, 1998 **Education and Training in Coastal Management: The Mediterranean Prospect**, Genoa, Italy, POCs: Darius Bartlett, Department of Geography, University College Cork, Ireland, phone (+353) 21 902835, fax (+353) 21 271980, e-mail DJB@UCC.IE; Adalberto Vallega, Scientific Coordinator, phone 39-10-209.5858, fax 39-10-209.5907, e-mail vallega@polis.unige.it; Secretariats: Stefano Belfiore, Francesca Borneto, Ombrina Pistarino, phone/fax 39-10-209.5840, e-mail iccops@polis.unige.it
- Jun 16 - 20, 1998 **PACON '98: Eighth Pacific Congress on Marine Science and Technology**, Seoul, Korea, POCs: Narendra Saxena, Hawaii, fax (808) 956-2580; Kenji Hotta, Japan, fax 81-47-467-9446; David Hopley, Australia, fax 61-77-755-429; Wang Ying, China, fax 86-25-330-6387; Hyung Huh, Korea, fax 82-345-408-5934.
- Jun 22 - 26, 1998 **ICCE 1998: 26th International Conference on Coastal Engineering**, Copenhagen, Denmark, POCs: ICCE 1998, Danish Hydraulics Institute, Agern Alle 5, DK-2970, Horsholm, Denmark, phone 45 45 76 95 55, fax 45 45 76 25 67; Billy L. Edge, Secretary, Ocean Engineering Research Council, Ocean Engineering Program, Texas A&M University, College Station, TX 77843-3136.

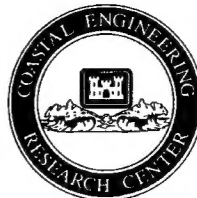


US Army Corps  
of Engineers  
Waterways Experiment  
Station

## The Corps' Coastal Vision Statement

We will, as the National Coastal Engineer:

- Continue our leadership in the protection, optimization, and enhancement of the Nation's coastal zone resources.
- Increase our contribution to the Nation's economy, quality of life, public safety, and environmental stewardship.

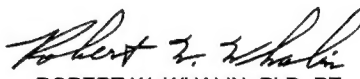


The **CERCular**  
Coastal Engineering Research Center

This bulletin is published in accordance with AR 25-30 as an information dissemination function of the U.S. Army Engineer Waterways Experiment Station. The publication is part of the technology transfer mission of CERC (an entity within the Coastal and Hydraulics Laboratory of WES) under PL 79-166 and PL 99-802. Results from ongoing research programs will be presented. Special emphasis will be placed on articles relating to application of research results or technology to specific project needs. Additional information and the CERCular can be found through the CHL Homepage at:

[http://bigfoot.cerc.wes.army.mil/CERC\\_homepage.html](http://bigfoot.cerc.wes.army.mil/CERC_homepage.html)

Contributions of pertinent information are solicited from all sources and will be considered for publication. Communications are welcomed and should be addressed to the U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory, ATTN: Dr. Lyndell Z. Hales, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or call (601) 634-3207, FAX (601) 634-4253, Internet: l.hales@cerc.wes.army.mil

  
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Director, WES



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